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Missoula County, Montana

National Eutrophication Survey, Corvallis, Oreg

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MONTANA

EPA REGION VIII

WORKING PAPER NO. 799

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

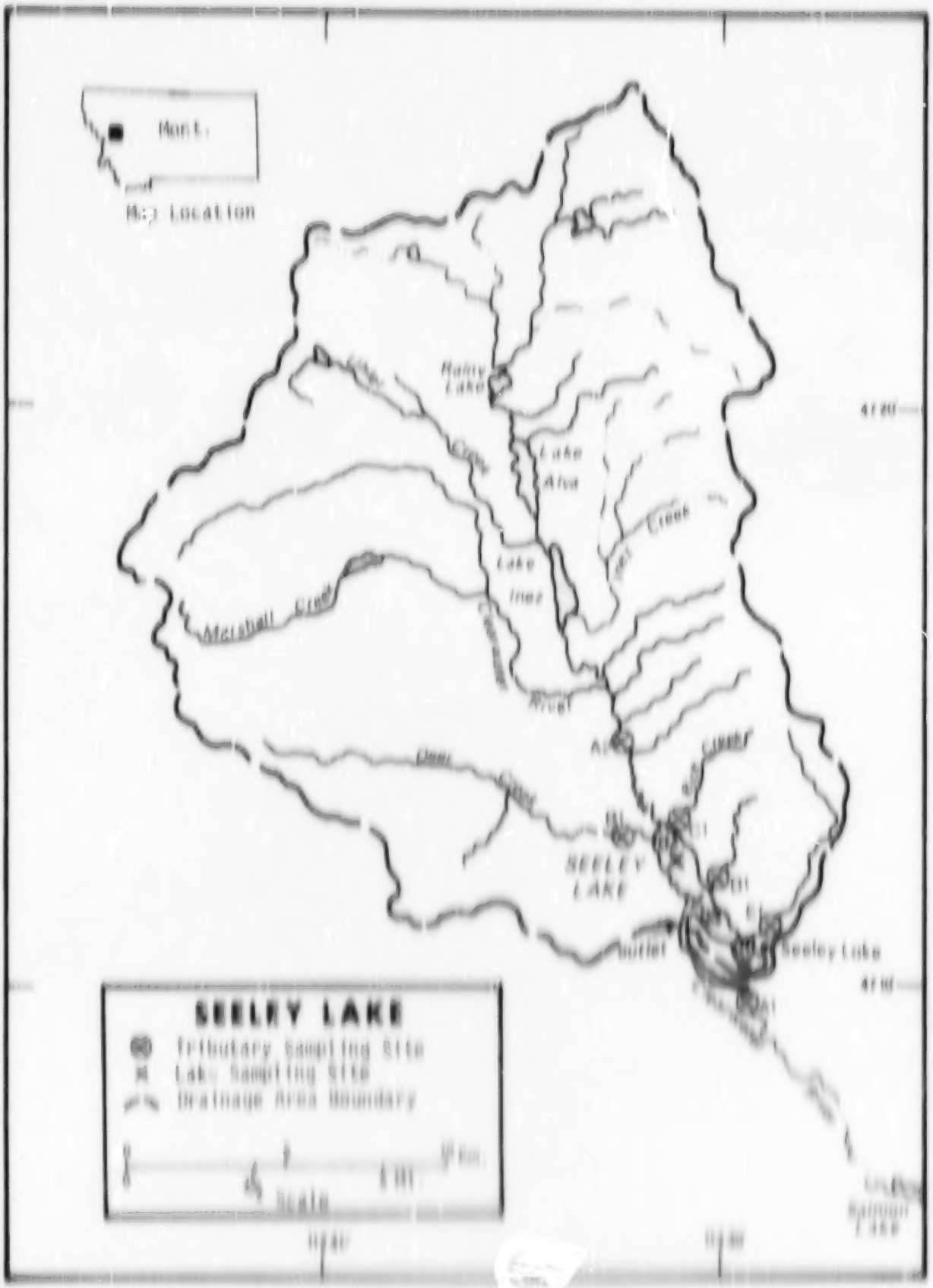
The staff of the National Eutrophication Survey (Office of Research & Development, U.S. Environmental Protection Agency) express sincere appreciation to the Montana Department of Health and Environmental Sciences for professional involvement, to the Montana National Guard for conducting the tributary sampling phase of the Survey, and to those Montana wastewater treatment plant operators who voluntarily provided effluent samples.

The staff of the Water Quality Bureau provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General John J. Womack, the Adjutant General of Montana, and Project Officer Major William Yeager, who directed the volunteer efforts of the Montana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY
STUDY LAKES AND RESERVOIRS
STATE OF MONTANA

LAKE NAME	COUNTY
Canyon Ferry	Broadwater, Lewis and Clark
Clark Canyon	Beaverhead
Flathead	Flathead, Lake
Georgetown	Deer Lodge, Granite
Hebgen	Gallatin
Koocanusa	Lincoln, MT; British Columbia, Can.
Mary Ronan	Lake
McDonald	Flathead
Nelson	Phillips
Seeley	Missoula
Swan	Lake
Tally	Flathead
Tiber	Liberty, Toole
Tongue River	Big Horn
Whitefish	Flathead
Yellowtail	Carbon, Bighorn, MT; Bighorn, WY


Mont.
Map Location
Rainy Lake
Lake Alva
Creek
Lake Inez
Marshall Creek
Creek
River
Deer Creek
SEELEY LAKE
Outlet
Seeley Lake
SEELEY LAKE
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
Scale

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Seeley Lake is meso-eutrophic. It ranked sixth in overall trophic quality when the 15 Montana lakes and reservoirs sampled in 1975 were compared using a combination of six water quality parameters*, five of the water bodies had less median total phosphorus, nine had less median dissolved orthophosphorus, none of the others had less but four had the same median inorganic nitrogen, four had less mean chlorophyll a, and six had greater mean Secchi disc transparency. Marked depression of dissolved oxygen with depth occurred at stations 1 and 2 in September.

Survey limnologists noted submerged and emergent macrophytes along the shoreline during the September sampling. Periodic dominance of blue-green algae in the early autumn and abundant emergent macrophytes have been noted in another study (Cladouhos, 1971).

B. Rate-Limiting Nutrient:

The algal assay results are not considered representative of conditions in the lake at the time the samples were collected (05/28/75 and 09/04/75) due to significant changes in nutrient concentrations during shipment of the samples from the field to the laboratory.

* See Appendix A.

The lake data indicate nitrogen limitation at all stations and sampling times with the exception of station 3 in September.

6. Nutrient Controllability:

1. Point sources--No known municipal or industrial point sources impacted Seeley lake during the sampling year. Septic tanks serving lakeshore dwellings, resorts, and campgrounds are estimated to have contributed 1.2% of the total phosphorus load; however, a shoreline survey would be necessary to determine the actual contributions of those sources.

The present phosphorus loading of 0.97 g/m^2/year is more than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as an oligotrophic loading but less than his suggested eutrophic loading (i.e., a mesotrophic loading; see page 11). Cladouhos (op. cit.) notes that Seeley Lake is potentially productive due to its morphometry, including the unique position of the outlet which causes poor circulation in the southern portion of the lake and accumulation of nutrients there.

2. Non-point sources--Non-point sources contributed 98.8% of the total phosphorus input during the sampling year. The Clearwater River contributed 64.6%, Deer Creek contributed 21.0%, and Seeley Creek contributed 1.9%. Ungaged minor tributaries and immediate drainage contributed an estimated 9.9% of the total.

A study of land-use practices in the drainage is needed to determine whether any significant reduction of non-point nutrient inputs can be accomplished.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 3.49 kilometers^2.
2. Mean depth: 18.3 meters.
3. Maximum depth: 36.6 meters.
4. Volume: 63.867 x 10^6 m^3.
5. Mean hydraulic retention time: 127 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Clearwater River	273.2	4.000
Deer Creek	61.3	0.763
Seeley Creek	13.2	0.111
Minor tributaries & immediate drainage -	37.2	1.007
Totals	374.9	5.881**

2. Outlet -

Clearwater River	378.4***	5.820

C. Precipitation****:

1. Year of sampling: 66.6 centimeters.
2. Mean annual: 57.5 centimeters.

† Table of metric conversions--Appendix B.
†† Norpchtad, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Sum of inflows adjusted to equal outflow plus evaporation.
*** Includes area of lake.
**** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Seeley Lake was sampled three times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations in May and July and from three stations in September (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first and last visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 18.9 meters at station 1, 34.1 meters at station 2, and 7.9 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table.

| | | |

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/28/75	1. Dinobryon sp.	826
	2. Melosira sp.	425
	3. Cryptomonas sp.	142
	4. Flagellates	142
	5. Fragilaria sp.	71
	Other genera	93
	total	1,699
07/29/75	1. Chroomonas sp.	341
	2. Fragilaria sp.	289
	3. Melosira sp.	210
	4. Dinobryon sp.	105
	5. Asterionella sp.	26
	Other genera	53
	total	1,024
09/04/75	1. Dinobryon sp.	425
	2. Fragilaria sp.	297
	3. Cryptomonas sp.	170
	4. Flagellates	170
	5. Anabaena sp.	85
	Other genera	102
	total	1,529

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
05/28/75	1	2.5
	2	2.1
	3	*
07/29/75	1	2.5
	2	1.3
	3	*
09/04/75	1	2.6
	2	2.0
	3	2.0

C. Limiting Nutrient Study:

The algal assay results are not considered representative of conditions in the lake at the times the samples were collected (05/28/75 and 09/04/75) due to significant changes in nutrient levels during shipment of the samples from the field to the laboratory.

The lake data indicate nitrogen limitation at all sampling stations and times with the exception of station 3 in September. Following is a tabulation of the mean inorganic nitrogen/ortho-phosphorus ratios for each sampling station and time with the indicated limiting nutrient in parentheses.

Station	05/28/75	07/29/75	09/04/75
1	4/1 (N)	5/1 (N)	8/1 (N)
2	3/1 (N)	5/1 (N)	13/1 (N-P)
3	.	.	20/1 (P)

IV. NUTRIENT LOADINGS
(See Appendix I for data)

For the determination of nutrient loadings, the Montana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff month of July when two samples were collected at most of the sites. Sampling was begun in October, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Montana District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in $kg/km^2/year$, at stations B-1 and C-1 and multiplying the means by the ZZ area in km^2.

No known wastewater treatment plants impacted Seeley Lake during the sampling year.

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

* See Working Paper No. 175.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Clearwater River	2,185	64.6
Deer Creek	710	21.0
Seeley Creek	50	1.5
b. Minor tributaries & immediate drainage (non-point load) -	335	9.9
c. Known municipal STP's - None	-	-
d. Septic tanks* -	40	1.2
e. Known industrial - None	-	-
f. Direct precipitation** -	60	1.8
Total	3,380	100.0

2. Outputs -

Lake outlet - Clearwater River 2,105

3. Net annual P accumulation - 1,275 kg.

* Estimate based on 90 shoreline dwellings, two resorts, and three campgrounds (Cladouhos, 1971); see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Clearwater River	49,605	63.9
Deer Creek	13,066	17.2
Seeley Creek	1,825	2.4
b. Minor tributaries & immediate drainage (non-point load) -	7,310	9.6
c. Known municipal STP's - None	-	-
d. Septic tanks* -	1,490	2.0
e. Known industrial - None	-	-
f. Direct precipitation** -	3,770	4.9
Total	76,065	100.0

2. Outputs -

Lake outlet - Clearwater River	115,975

3. Net annual N loss - 39,910 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Clearwater River	8	178
Deer Creek	14	255
Seeley Creek	4	138

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean total P Conc. (mg/l)	Mean total N Conc. (mg/l)
Rice Creek	0.013	0.528
Auggie Creek	0.027	0.621

* Estimate based on 90 shoreline dwellings, two resorts, and three campgrounds (Cladouhos, 1971); see Working Paper No. 175.
** See Working Paper No. 175.

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.97	0.37	21.8	loss*

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Seeley Lake:

"Dangerous" (eutrophic loading)	1.36
"Permissible" (oligotrophic loading)	0.68

* There was an apparent loss of nitrogen during the sampling year. This may have been due to nitrogen fixation in the lake, solubilization of previously sedimented nitrogen, recharge with nitrogen rich ground water, unknown and unsampled point sources, or underestimation of the nitrogen loads from lakeshore dwellings. Whatever the cause, a similar nitrogen loss has occurred at Shagawa Lake, Minnesota, which has been intensively studied by EPA's former National Eutrophication and Lake Restoration Branch (Maluey et al., 1975).

V. LITERATURE REVIEWED

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Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

| | | |

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.,81 = fuet

Cubic meters x 8.107 x 10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

| | | |

APPENDIX B

PHYSICAL and CHEMICAL DATA

APPENDIX E

TRIBUTARY DATA

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